Water and energy in South Africa – managing scarcity

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ABSTRACT

In this paper we examine the nexus of water an energy scarcity in South Africa. The fresh water resources of the country are close to exhaustion (Business Day, 2009; Turton, 2008), yet safe drinking water is not yet universally available to all in the country – in spite of a government policy to provide water for basic needs, taken to be 25ℓ per person per day (Coovadia, Jewkes, Barron, Sanders, & McIntyre, 2009). A growing economy and a population now close to 50 million have also put considerable strain on the electricity supply and distribution system, including wide-spread residential power outages in the main economic centers and, since January 2008, mandatory cuts for industrial users (Patel, 2008). The paper provides an overview of the current system in South Africa for supplying and managing water and electricity – for residential, industrial and for agricultural use – with a special emphasis on the energy requirements for delivering water as well as the water required in generating electric power. Finally we consider the example of Australia, another country with severe water shortages and one with a comparable demand for electricity, and attempt to draw lessons for South Africa from Australia's more market-driven approach to energy and water.

INTRODUCTION

The developments around water and energy in South Africa should be seen against the background of the inter-related facts of

- the geographic endowment of the country, being exceptionally rich in mineral resources but poor in water;
- rapid economic growth and industrialization since the late 19th century;
- population growth and persistent and large socio-economic inequalities; and
- patterns of government investment in infrastructure.

All four factors have a distinct political aspect, which will be discussed only in so far it has specific relevance to the provision and management of water and energy.

South Africa (SA) has a famously temperate climate. However, seasonal rainfall is subject to several cycles (Tyson, Cooper, & McCarthy, 2002) and variability in rainfall has tended to have a marked effect on economic growth even though agriculture accounts, directly, for less than 5% of economic activity (Jury, 2002). The higher rainfall areas of SA are, further, on or close to the eastern seaboard (Turton, 2008) whereas mineral resources and urban settlement are concentrated in the drier central western and northern parts of the country, especially the Bushveld Igneous Complex (Clarke, Uken, & Reinhardt, 2009), Witwatersrand Basin which is thought to have been the source for near 40% of all gold ever mined (Frimmel, 2002) and the kimberlite regions (Field, Stiefenhofer, Robey, & Kurszlaukis, 2008). Mining has not only been a chief influence on the pattern of human settlement and industrial development in the country, with a typical core-periphery pattern (Krugman, 1991) emerging, but is also major consumer of both water and energy as well as being responsible for significant environmental degradation (Adler, Claassen, Godfrey, & Turton, 2007). In South Africa, the main population center – the conurbation around and connecting Johannesburg and Pretoria – is not only far from major water sources but is actually *on* the continental divide. Mean annual precipitation for SA is 497mm/year, compared to a global mean of 860mm/year which makes the country only a bit less dry than Botswana (Turton, 2008).

Over the 20th century, South Africa experienced relatively modest growth in gross domestic product (GDP) per capita, compared to nations outside the African continent, but robust population growth has ensured that the GDP of SA nearly caught up with that of Australia over the period 1913–1989 (see Table 1). Moreover, South Africa has experienced significant industrialization over the past century and today boasts i.a. a nuclear power industry, advanced car manufacturing and research and design excellence in several areas with the attendant demand for water and energy.

		South Africa	Australia
Population	1913	6 214	4 821
(000s)	1989	34 925	16 807
GDP ($)	1913	2 037	4 553
per capita	1989	5 627	13 538
GDP ($m)	1913	12 658	21 950
	1989	196 523	227 533

Table 1: GDP of South Africa and Australia in 1985 US dollars (Maddison, 1994)

The population of South Africa at the beginning of the 19th century is estimated to have been a mere 1½ million and had grown to around 4 million by the beginning of the 20th century (Feinstein, 2005). The mid-year population estimate for 2009 is 49 million (Statistics South Africa, 2009). A population increase of this scale is not unusual for an African country (Aluko, 1965) but SA's high human development index (HDI) and the increase in the HDI over the past century (Crafts, 2002) have, together with the moderately higher GDP per capita, probably exacerbated the problem of rising demand for basic services. To some extent these services will have to remain subsidized, whether directly through "free" allocations of water and electricity to households or indirectly through the payment of social grants, since as many as ⅓ of households could be trapped in chronic poverty (Carter & May, 2001) and as many again experience periodic poverty. It is not politically feasible to deny such a large section of the population access to energy and potable water.

Finally, government investment in infrastructure has been strongly correlated with economic growth in South Africa (Fedderke, Perkins, & Luiz, 2006). Progressive tax policies evolved in South Africa, in contrast to similar countries like Brazil (Lieberman, 2001), and the resources appropriated in this way by the state have been used to some extent to finance infrastructural investments. However, public-sector economic infrastructure investment peaked in the mid-1970s and went into precipitous decline in the mid-1980s (Perkins, Fedderke, & Luiz, 2005) as unrest among the poor majority forced the state to turn its resources to social and security spending. In 2009, poor communities have again erupted in violent protest about municipal services (BusinessDay, 2009a; IOL, 2009a) and, given that the incidence of poverty in SA is still increasing (Agüero, Carter, & May, 2007), there is little immediate prospect for relief of the political pressure which so dramatically started detracting attention from public investments a quarter of a century ago.

This is the background, then, of water and energy policy in South Africa – general aridity, substantial mineral resources, the exploitation of which, together with strong population growth and industrial development, compete with the political imperative of providing basic services for a growing underclass which is mired in chronic poverty for the available resources of the environment and of the state.

WATER

Essentially all water available in South Africa, has been allocated (Turton, 2008). As a result, eutrophication in bodies of fresh water is a major concern will increase even if demand for water were to stay constant (Oberholster & Ashton, 2008). A new National Water Act (1998) has been passed (Kidd, 2009) but the implementation of integrated water resources management by the Department of Water affairs and Forestry has been less aggressive than was expected (Jonker, 2007).In this section, a broad overview of the future development of the country's water resources is given, with the emphasis on the energy requirements of water provision in a country where many millions of people already drink water captured in reservoirs more than 400km away, some of it pumped across the continental divide *twice* for Tugela water to reach residents of the administrative capital, Pretoria (Van Robbroeck, 1975). Cross-border water management issues in the Orange-Vaal and Limpopo catchment areas are also briefly reviewed.

Water and the law

Prior to the National Water Act of 1998, riparian rights formed the basis of water allocation in South Africa. This emphasis developed in the 19th century, as Anglo-American legal thought influenced the Roman-Dutch law which had held sway until the English occupation of the Cape (Kidd, 2009). The Roman-Dutch principle of the state as *dominus fluminis* was revived in SA by the 1998 Act which ordained the Minister of Water Affairs and Forestry as trustee, on behalf of the national government, of the nation's water resources. Section 27 of the 1996 Constitution of the Republic of South Africa, guarantees to each person a "right to have access to" i.a. food and water which is interpreted as a duty on the state only to provide those commodities to individuals who are deemed not to be able to procure them through their own efforts (Gabru, 2005). With respect to water, the Water Services Act 108 of 1997 enacted this right to water, by determining that no water authority may refuse to give access to services to any consumer within its jurisdiction. The current Basic Free Water Policy provides 6 000 liters per month, free of charge, to each household but the introduction of the policy has been accompanied in some localities by a more stringent metering regime and attempts to inculcate a "culture of payment" among the urban poor (Greg Ruiters, 2007) and should – in view of the relative modesty of the allocation – not be seen as purely contradicting the principle of payment for municipal services.

Water in agriculture

Agriculture (excluding forestry) is by far the biggest user of water in South Africa, consuming 64% of the water considered in the 2000 water accounts for SA – at an average price of R0.023 per m^3, compared to the average price of R12.00 per m^3 paid by the trade and services sector and R1.19 paid for domestic use (Statistics SA, 2006). The fraction of water used by agriculture is even higher if one considers the abstraction of soil water by dryland crops. Historically, water for agriculture had been an important political tool in SA, as it has been in many other countries (De Gorter & Swinnen, 2002). Agriculture in SA is mainly large-scale capital-intensive and its impact on water quality, because of the high use of agrochemicals is substantial (Bamuza-Pemu & Chirwa, 2008; Dabrowski, Murray, Ashton, & Leaner, 2009).For this reason, any plan to address South Africa's water scarcity cannot overlook the, arguably wasteful, application of this resource to crop production.

Water and mining

Mining activities use 3% of the available water yield of South Africa (Statistics SA, 2006). This seems, modest, compared to the contribution of mining activities to the country's gross domestic product (GDP). However, past and present mining activities contribute significantly to environmental degradation – especially in the northern parts of the country. Ground water in the region of Johannesburg, feeding into streams, has been seriously contaminated by heavy metals and is highly acidified due to drainage from gold mine dumps (Cobbing, 2008; Naicker, Cukrowska, & McCarthy, 2003). Not far from Johannesburg, in the eastern province of Mpumalanga, abandoned coal mines have caused similar problems in the watershed of the Olifants river (Bell, Halbich, & S. Bullock, 2001), which eventually flows into the Kruger National Park. In the same area, as well as south of Johannesburg, spontaneous combustion of coal has also been a problem (Pone et al., 2007) of uncertain severity but of undoubted public impact.

There has been growing global concern over the environmental impact of mining and especially acid drainage (Akcil & Koldas, 2006) which is of particular concern in the semi-arid environment of South Africa. Since mining in South Africa has been very capital intensive for most of the past century, a large degree of state control of the sector has been possible, but unseemly close relations have apparently developed between the mining industry and the national government. In early 2009, for example, it was reported that the mistress of the then president, herself an employee of the governing party, and the husband of the then Minister of Water Affairs and Forestry were both directors of Vuna Coal Holdings, a company mining coal near Middelburg, in a tributary of the Olifants River (IOL, 2009b) without a water license. Seven months later, under a new Minister, Vuna had still not obtained a license and was still operating (Volksblad, 2009).

Achieving any kind of political consensus about the costs and benefits of new mining projects, is made quite difficult by having three different national government departments are directly involved in the administration of issues arising from mining – Water Affairs and Forestry, Environmental Affairs and Tourism as well as the Department of Minerals and Energy (Oelofse, 2008). Further, the Department of Trade and Industry regulates various aspects of the legislated regime of racial preferences that applies, in principle, to all South African businesses (Southall, 2004). Even though the regulatory approach to mining is fragmented and often very ineffective, it can be argued that mining is now supported and constrained by a legal framework that has the potential for promoting long-term sustainability of the industry and of the environment (Adler et al., 2007).

Residential use of water

Urban domestic use accounts for a mere 12% of the available water yield of the country (Statistics SA, 2006). Nevertheless, the treatment of household effluent is a matter of serious concern due to the loss of dilution capacity (Turton, 2008).Overloaded municipal sewage works are a cause of pollution threatening the environment as well as prime agricultural land (De Villiers, 2007). Just south of Johannesburg, the Klip River and Vaal Barrage waterways have been heavily polluted and high levels of fecal matter are present (McCarthy, Arnold, Venter, & Ellery, 2007; Tempelhoff, 2009). Pumps meant to discharge treated sewage into the Vaal River are often observed pumping *raw* sewage, some 60km from the center of Johannesburg (Tempelhoff, 2009), the greatest concentration of wealth and industry on the African continent. The author can confirm, anecdotally, that raw sewage is no longer an unknown sight on his street, in an upmarket suburban area of Pretoria.

The ability of local authorities to address problems with treatment of effluent is constrained by policy decisions such as the emphasis on the implementation of the Basic Free Water Policy as well as custodianship having, in cases, moved from sub-national authorities and public corporations to the national government (Tempelhoff, 2009). In 2005, it was reported that only 70 of 278 municipalities in SA employ any civil engineer(s) at all (Lawless, n.d.). Engineers have historically been drawn from the minority of European descent and this group has suffered high levels of emigration as well as employment policies that reserve many positions for individuals of non-European descent. A backlog in maintenance and investment in municipal sewage treatment will increasingly become manifest in all urban areas (IOL, 2008).

Rainfall enhancement and water from further afield

In the 1970s, South Africa started experimenting with cloud seeding and other techniques for rainfall enhancement, i.e. to capture some of the 90% of cloud-borne moisture that crosses South Africa without manifesting as precipitation (Shippey, Görgens, Terblanche, & Luger, 2007).Experimental results suggest that a modest increase in rainfall in the region of 10% can be obtained in this way (Terblanche, Mittermaier, Burger, de Waal, & Ncipha, 2007) which would have obvious socio-economic benefits but would not obviate the underlying water shortage, in the long run.

Two large water transfer projects currently supply water to the industrialized Gauteng province, around the cities of Johannesburg and Pretoria, as well as further afield. The Tugel-Vaal project transfers water from the eastern seaboard to the Vaal system by using off-peak electricity to pump water across the Drakensberg from near the source of the Tugela River, to the Sterkfontein reservoir (Van Robbroeck, 1975) over a modest distance and altitude of some 500m (Rand Water, n.d.) from where water enters the natural drainage system of the Vaal river tributaries and eventually the Orange River. This scheme has added substantially to the natural yield of the Vaal. Further, the Lesotho Highlands Water Project (LHWP) diverts water from the upper reaches of the Orange in the Lesotho mountains to the Vaal catchment area, using a series of tunnels to deliver water to the Vaal basin at a point not far from the Sterkfontein dam (Matete & Hassan, 2005). The Zambezi river carries ten times as much water as South Africa's Orange River (Swatuk, 2002) and is occasionally mentioned as a candidate for further inter-basin water transfer. However, the Vaal is the only substantial river in the Gauteng region and it is more than 1000km from the Zambezi which renders this quite a far-fetched idea. Instead, discussion has centered around extending either the Tugela or the LHWP schemes (Engineering News, 2008).

Cross-border water management

The Kingdom of Lesotho is a mountainous country entirely surrounded by the Republic of South Africa. Lesotho is ethnically homogeneous but almost entirely dependent on South Africa economically. Even though the two countries are dramatically unequal, the water transfer treaty governing the Lesotho Highland Water Project (LHWP) has proved durable and has provided a mutually beneficial framework for settling all disputes that have arisen (Boadu, 1998). Construction on the project was started in 1987 and although both countries have gone through some political turbulence since, the treaty and project have not suffered adversely.

The Orange River drains around half of the South African territory, including both ends of the LHWP transfer project, and is by far the largest river in the country (Swanevelder, 1981). Its drainage basin also includes parts of Botswana and Namibia, where it forms the most important part of that country's border with South Africa. In its lower part, the Orange River flows through a beautiful mountainous desert with a very low population density and almost no industrial activity and only modest agricultural use, many hundreds of kilometers from its mouth. The 1990 Constitution of Namibia stipulates the middle of the Orange as the country's southern border (Conley & Van Niekerk, 2000) but South Africa claims the Namibia bank of the river as the border and the dispute is ongoing.

Botswana, Zimbabe, South Africa and Mozambique share Rudyard Kipling's “great grey-green, greasy Limpopo,” which drains a large part of South Africa, together with its tributary the Olifants which joins it in Mozambique as the *Rio dos Elefantes*. In 1986 a Limpopo Basin Permanent Technical Committee was established but it remained moribund until 1995 since which time it has met periodically. On the upper Limpopo, South Africa and Botswana have jointly managed the apportioning of water and other issues since 1967 (Heyns, 2003). The Limpopo itself, although forming the longest part of the borders with Botswana and with Zimbabwe, does not serve large concentrations of population inside South Africa and for most of the year has at most modest flow within the Republic.

Water use and energy

Water is a key resource for the production of energy and since South Africa has a shortage of both, planners should aim to be parsimonious in both areas. The amount of water consumed in the production of electricity in South Africa is already of the same order of magnitude as the water use of the mining industry (Statistics SA, 2006). Alternative energy sources have differing water requirements and as such the imperatives of water management should play a role when making decisions regarding energy production. The use of biofuels, for example, is a very water-intensive choice (Rio Carrillo & Frei, 2009) and it is surprising that South Africa has been considering biofuel investment at all. Hydro-electric power also consumes water resources that could have been applied elsewhere, e.g. in Scotland where the generation of hydro-electricity is now the single largest consumer of water (MacLeod, Moran, & Spencer, 2006).In South Africa, unscheduled interruptions in the electricity supply has also caused appreciable pollution of water sources (African Energy News Review, 2008).

ELECTRICITY

Since January 2007, when unplanned outages of more than 10% of generating capacity occurred on a single day, South African consumers and industry have been plagued by planned and unplanned power outages (IOL, 2007; Reuters, 2007). The cost to the economy and reputation of the country have been substantial, including lost investment such as a planned aluminum smelter at Coega in the economically depressed province of the Eastern Cape (IOL, 2009). The economic slowdown of 2008 and already substantial price increases of 27% and 31.3% consecutively (Leadership Online, 2009) have ameliorated the situation but, again anecdotally, the author of this paper experienced more than one power outage while working on it. The principle causes of the power outages, euphemistically called “load shedding” in SA, appear to be

- insufficient generating capacity to allow for adequate maintenance of the plants;
- national transmission capacity not allowing consumption in relatively isolated nodes like Cape Town to be supplied from elsewhere; and
- aging distribution infrastructure in the urban areas.

The political imperative of keeping prices for residential consumers low, appears to have been jettisoned (Engineering News, 2009) with a further three years of 45% [sic] consecutive annual increases likely to be approved. Although South African consumers are fond of blaming Eskom for the current crisis, it should be said that anyone who cared to read a 1998 White Paper would have been aware of the following.

> “Eskom’s latest Integrated Electricity Plan forecasts for an assumed demand growth of 4,2% that Eskom’s present generation capacity surplus will be fully utilised by about 2007. Timely steps will have to be taken to ensure that demand does not exceed available supply capacity and that appropriate strategies, including those with long lead times, are implemented in time. The next decision on supply-side investments will probably have to be taken by the end of 1999 to ensure that the electricity needs of the next decade are met.”
>
> (Department of Minerals and Energy, 1998)

South Africa's president of 1999–2008, Mr Thabo Mbeki, is reported to have admitted in December 2007 that

> “Eskom was right. We were wrong.”
>
> (Patel, 2008)

Government's decision in 2001 (rescinded in 2004) not to allow Eskom to invest in further capacity, in expectation of the entry of independent producers to the market, is not solely to blame for the fiasco. Racial preferences in hiring and procurement at Eskom was another factor that decreased the utility's capacity for coping the impending crisis and, indeed, a ban at Eskom on the hiring of males of European descent (who are though to comprise a majority of all South African engineers) was only lifted in 2008 (The Centre for Development and Enterprise, 2008).

Power generation

At the moment, electricity for all uses in South Africa is provided by a monopoly supplier, Eskom, established in 1923 as the Electricity Supply Commission, which is the 13th largest generator in the world (Patel, 2008). Production is mainly in large thermal power stations, using the country's abundant coal resources which are used to produce 92% of South Africa's electricity (Worthington, 2008), the remainder being generated using gas turbines, hydro-electric power (including pump-storage facilities) and the nuclear power plant at Koeberg, near Cape Town. Eskom is currently building two very large coal-fired plants – the 4 788-MW Medupi plant and the 4 800-MW Kusile facility – as well as recommissioning three smaller thermal plants that had been moth-balled (Patel, 2008). There has also been new investment in transmission capacity. Eskom is hoping to finance this expansion by a retail price *increase* of over 400% in total, spread over five years. In relation to the Medupi project, the largest contract in Eskom's history was granted to a joint venture between Hitachi and a funding arm of the ruling party (Engineering News, 2007; Mail & Guardian Online, 2007) so political support for these projects should be assumed to be solid.

Distribution of electricity

In 2009, Eskom and 187 municipalities were responsible for the distribution of electricity to consumers and other users. Some of the large cities have operated their own small power plants as well and utilized the provision of electricity as a revenue stream. Residents of the localities of Bultfontein and Hoopstad in Free State province are reported to pay R3.11 per kWh (approximately $0.40 US) for electricity, whereas R0.4254 is the rate approved in Cape Agulhas (Sake24, 2009).

The national government established Electricity Distribution Industry (EDI) Holdings in 2003, to oversee the process of creating region electricity distributors (REDs) that would become responsible for distribution of power generated by Eskom as well as independent producers. The first RED was established in Cape Town in 2005 but collapsed in 2006 (Business Report, 2006). In 2009, enabling legislation was before parliament to facilitate a renewed attempt at establishing six REDs but 40 of the distributing municipalities had not yet signed up for the project (Parliamentary Monitoring Group, 2009).

Electricity use

At 66%, industry uses the bulk of electricity produced in South Africa with the remainder divided between residential, commercial, transport, agricultural and mining use (Worthington, 2008). Price elasticity of demand for residential electricity has been found to be insignificant in South Africa (Ziramba, 2008) but perhaps at historically prevailing price levels and not at the levels proposed for the near future. The role of fixed prices in the long-term contracts of Eskom's industrial customers, has not been investigated in sufficient detail.

Renewable energy sources and nuclear energy

Historically low electricity tariffs have been very detrimental to the development of renewable energy generation in South Africa (Winkler, 2005). Solar and wind energy are obvious candidates for relatively widespread use and, indeed, in many South African cities one can see solar-powered traffic signals that were installed in response to load-shedding by Eskom but these are not cost-effective (Coetzee, Louw, & P. J. Bullock, 2008) but merely serve to obviate the secondary effect of terrible traffic snarls during blackouts. In March 2009 however the National Energy Regulator of SA set feed-in tariffs of R1.25 per kWh for renewable energy and private wind farms are expected to soon join those operated already by Eskom (BusinessDay, 2009b).

At Koeberg, just north of Cape Town, Eskom runs two pressurised water reactors which constitute Africa's only nuclear power plant which has been connected to the grid since 1984 (Eskom, n.d.). Plans to build a new nuclear were cancelled in late 2008 (MiningMX, 2008).

Energy and water

The extensive use of coal in power generation in South Africa has an appreciable environmental impact. This impact is manifested is several distinct ways, including:

- water consumption of around 2ℓ per kWh for cooling in the older coal-fired power stations (Worthington, 2008); and
- degradation of water quality in various ways, including acid-runoff.

Further, efforts to reduce particularly harmful atmospheric emissions can require increased use of water and here pollution standards could possibly have unintended consequences (Engineering News, 2008). It is worth keeping in mind that Eskom is already SA's largest emitter of carbon emissions, at around half of the country's total of 440 million tonnes, which has it at 12^{th} position in the world (Reuters, 2009).

Despite, or because of, its high environmental impact, Eskom has pioneered dry cooled thermal power generation and its Medupi station, under construction in the province Limpopo, will be the largest dry-cooled power plant in the world (Parrock, Van Jaarsveld, & Deale, 2009).

MARKET-BASED LIBERALISATION

South Africa has lagged behind in reform of the electricity and water markets and this is now widely regarded as one of the major challenges facing the country. Australia, which has similar resources as South Africa (lots of coal, little water) has establish a National Electricity Market in 1998 (Abbott, 2006) and recently launched a permanent nation-wide system for trading water rights, that is perhaps the most comprehensive in the world (Brooks & Harris, 2008). In this section, we consider possible lessons for South Africa in the Australian system and mention problems of economics that can emerge in a market-based system.

Markets in water

South Africa's Water Act of 1956 had also distinguished between *public* and *private* water, and explicitly prohibited the sale of the latter. Historically, the water management regime has therefore been inimical to any kind of trade. Research has suggested that appropriate water charges would reduce scarcity, boost economic growth and alleviate poverty (Letsoalo et al., 2005).At the moment the transfer of water rights in SA is subject to numerous bureaucratic obstacles and according to reports 99 000 hectares of irrigation land are now out of production because of a refusal by the Department of Water and Environmental Affairs to approve the transfers on the basis of the ethnic background of the parties involved.

Like SA, Australia is dominated by a single river system (the Murray-Darling) which has a very long inland watercourse, running through arid or semi-arid areas from its source on the “wrong” side of a north-south dividing range. Such a river, like America's Colorado, is an obvious and tempting resource for irrigation agriculture. Since the 1980s, Australia has been expanding water markets in an effort to more efficiently allocate the resource and studies have demonstrated substantial economic benefits (Brooks & Harris, 2008). However, even in Australia, where inter-state water trading, farmers are still not allowed to sell water rights to urban areas (Farm Weekly, 2009) unlike the United Stated where inter-sectoral trade does take place. Since Australia and South Africa have a similar legal background, it seems logical that SA should look to Australia for lessons creating a water market.

Markets in energy

Some international trade in electricity takes place throught the Southern African Power Pool (SAPP) which uses i.a. Inexpensive hydro-electric power from Mozambique, Zambia and the Congo (Kinshasa) to supplement the thermal power of South Africa (Bowen, Sparrow, & Yu, 1999). For the domestic market, there is almost no market mechanism for regulating use. Instead, the utility has been counting on public service announcements in the media to convince consumers to curtail their use of energy during peak periods. Unlike Australia, there are no off-peak reduced prices for household electricity and prices are fixed but the service provider (usually a municipality) for 12 months in advance. The South African media have also deployed name-and-shame campaigns where lights have been left on in offices overnight and a certain sensitivity towards this minor excess has developed. Clearly, the full implementation of the separation of distribution and generation, as foreseen in the national governments planning (Department of Minerals and Energy, 1998) that would be necessary for the development of a whole-sale market is till far off (Parliamentary Monitoring Group, 2009).

In Australia, mechanisms in operation range from off-peak pricing for the retail market (which has largely solved the problems with hot water heaters during peak periods) to a spot market in which producers and consumers trade 24 hours per day using a specific bidding mechanism and prices are published every 30 minutes. On Australia's National Electricity Market (NEM), prices per megawatt-hour are allowed to range between -1 000 [sic] and 10 000 dollars and both of these limits cap in practice be reached. The NEM covers the five eastern states of Australia, a market similar in size to that of South Africa, with many independent producers and owners of transmission capacity (Chester, 2006). The Australian history of independent electricity generators in the various states, has allowed the independent producers to emerge. Unfortunately, South Africa has no comparable history, except for generation by the municipalities which recent policy has sought to curtail or stop.

Problems with markets in electricity and water

This final subsection shall concern itself not with the conflict between social and political imperatives and economics efficiency but restricts itself to pointing to several difficulties likely to arise within an appropriate market mechanism.

First, the effect of a wholesale market on investment in power generation has not been the subject of extensive studies (Kagiannas, Askounis, & Psarras, 2004). Electricity networks have a specific structure with regard to transmission and examples have been constructed where a decrease in market concentration (i.e. the introduction of new suppliers) can lead to a *less* efficient outcome (Berry, Hobbs, Meroney, O'Neill, & Stewart, 1999).

Second, consumers of energy might need to accept that an efficient market that guarantees 100% availability might not be possible and that interruptible-service incentive contracts will probably be required if a flexible and efficient market were to be created (Rassenti, Smith, & Wilson, 2002). Consumers are used to being “bumped” from commercial airline flights and there is no reason to think that a more efficient electricity market won't require consumers to either accept more power outages or pay a premium for a highly reliable service.

Third, trade in water permits needs to take into account the definite spatial aspect of water use (Heaney, Dwyer, Beare, Peterson, & Pechey, 2006). Whereas electricity is relatively easily transferred from point to point, the same is not true of water. Consider an irrigation farmer near Upington on the Orange River, who would decide to sell his water rights to the city of Sasolburg, far upstream on the Vaal River. The water now extracted by Sasolburg would simply disappear from the watercourse between Sasolburg and Upington, where it would normally have flowed in a condition no less poluted than it was when passing Sasolburg. All users of water as well as property owners downstream from Sasolburg could now be faced – unless Sasolburg treated all the water it had taken to a condition no less pure than when extracted and returned it to the watercourse – with a water resource with diminished dilution capacity and, consequently, a more polluted one. If the farmer had taken the water at Upington and trucked it to Sasolburg, the effect on users in between would be neutral but Sasolburg would have received a less pristine quantity of the resource. This is the very reason why Australia has limits on the trading of water across regional boundaries. Although the case for trading water permits is strong, it is clear that a past association between property and water rights was not without foundation.

CONCLUSION

This paper has, hopefully, emphasized that South Africa's electricity and water supply problems should not be treated independently although both are severe and demand urgent attention. The severity of the electricity crisis that started in Cape Town in 2006 has demanded immediate investment decisions and Eskom, not entirely unreasonably, has been demanding assurances of high retail prices in order to finance this investment. Since the electricity industry in South Africa has not been prepared for wholesale competition, further *ad hoc* management of the incumbent monopoly is the only immediate way forward. It should be noted that, as an sweetener for its proposed tariff increases, Eskom has argued that higher tariffs would create incentives for independent producers. This is, no doubt, true but the same argument would support arbitrarily high prices. Admirable legislation adopted in SA for integrated management of water resources have not seen a great practical adoption (Jonker, 2007). The distribution of water to consumers in certain urban areas has become more efficient since municipal functions have been outsourced to private operators but this efficiency has come at the price of stricter enforcement of free water limits and a more aggressive income recovery policy (McDonald & G. Ruiters, 2005) but the retail aspect of water provision has not been a main theme of this paper.

It should be kept in mind that the main purpose of markets, apart from expressing a natural freedom to trade, is the optimal allocation of scarce resources. The meaning of “optimal” here is rather technical and does not signify an complete satisfaction of all politically expedient goals. In general, free societies have chosen markets as one way to discover what “optimal” is, or have simply quietly accepted outcomes that have been determined by markets because the markets are seen to be free, transparent and, if not fair, at least impartial (Friedman, 2002). In many developing countries, however, more authoritarian regimes have been emerging after the heady days of the “end of history” and presumed advent of a universal free and democratic model of society (Diamond, 2008). The future of energy and of water in South Africa might be determined by whether the body politic decides to build on the country's experience of freedom and openness or whether it chooses, or is forced by circumstances to choose, another option.

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